بيروت، في ____________________

قرار رقم
المعايير والشروط الدنيا المتعلقة بعملية انتاج الوقود من النفايات

إن وزير البيئة،
بناء على المرسوم رقم 8376 تاريخ 2021/10/10 (تشكيل الحكومة)،
بناء على القانون رقم 216 تاريخ 1993/4/2 (إحداث وزارة البيئة)، لا سيما المادة الأولى منه،
بناء على القانون رقم 444 تاريخ 2002/7/29 (حماية البيئة)،
بناء على القانون رقم 690 تاريخ 2005/8/26 (تحديد مهام وزارة البيئة وتنظيمها)،
بناءً على القانون رقم 80 تاريخ 2018/10/10 (قانون الادارة المتكاملة للنفايات الصلبة)، لا سيّما المادة 22-ب منه،
وبعد استشارة مجلس شورى الدولة (الرأي رقم 2021/91-2022 تاريخ 2022/2/22، الرأي رقم 2023/61-2024 تاريخ 2024/1/23، الرأي رقم 2023/88-2024 تاريخ 2024/2/22)،

يقرّر ما يلي:

المادة 1 - تحديد المعايير والشروط الدنيا
تحدد المعايير والشروط الدنيا الواجب التقيّد بها بالنسبة لعملية انتاج الوقود من النفايات وفق أحكام الملحق المرفق.

يتوجب على كل جهة تتولى معالجة النفايات الصلبة البلدية من خلال انتاج الوقود اتخاذ الاجراءات الضرورية لوضع هذه المعايير والشروط الدنيا موضع التنفيذ.

المادة 2 - الملحق
يعتبر الملحق المرفق بهذا القرار جزءا لا يتجزأ منه.

المادة 3 - حق فرض معايير وشروط جديدة
تحتفظ وزارة البيئة بحق فرض معايير وشروط جديدة او تعديل اي منها عندما تدعو الحاجة.

المادة 4 - الغاء القرارات المخالفة
تلغى كافة القرارات المخالفة لأحكام هذا القرار او غير المتفقة مع مضمونه.

المادة 5 - نشر القرار والعمل به
ينشر هذا القرار ويعمل به فور نشره في الجريدة الرسمية ويبلّغ حيث تدعو الحاجة.

وزير البيئة
د. ناصر ياسين

Standards and Conditions for the production of alternative fuels from solid waste

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1. Scope

Law Number 80 regarding Integrated Solid Waste Management in Lebanon provides a general framework for solid waste management in the country. Article 1 and article 22 of this Law refers to the production of solid alternative fuels from waste materials, whereas a classification of solid alternative fuels is provided by the Ministry of Environment, decision 58/1/January 2020.

This regulation aims to establish minimum standards and conditions for facilities that produce solid alternative fuels through proper treatment of municipal solid waste and similar waste. These standards and conditions are applicable to any waste treatment plant that produces solid alternative fuels from municipal solid waste and similar waste.

The production of liquid fuels is excluded from the scope of this regulation. The production of solid fuels from hazardous waste is excluded from the scope of this regulation.

ANNEX 1 describes the role of solid alternative fuels in solid waste management.

ANNEX 2 presents waste streams suitable and waste streams excluded from the SAF production.

2. Definitions

For the implementation of this Decree, additionally, to the definitions of article 1 of Law No 80 "Integrated Solid Waste Management" dated 10 October 2018, the following definitions apply:

1. **Municipal waste**: means waste from households, as well as other waste which, because of its nature or composition, is like waste from households.
2. **Household Waste** is defined as waste produced within the curtilage of a building or self-contained part of a building used for the purposes of living accommodation.
3. **Food waste**: The organic residues generated by the handling, storage, sale, preparation, cooking, and serving of foods.
4. **Feedstock**: means waste that contains organic materials which decompose biologically.
5. **Biodegradation**: A process where organic materials are degraded by microorganisms.
6. **Biodegradable waste**: Any waste that can undergo anaerobic or aerobic decomposition, such as food and garden waste, paper, and paperboard etc.
7. **Residual Waste**: The fraction of collected waste remaining after a treatment or diversion step, which generally requires further treatment or disposal.
8. **Treatment/ Pre-Treatment** includes, in relation to waste, any manual, thermal, physical, chemical, or biological processes that change the characteristics of waste in order to reduce its volume, or hazardous nature or facilitate its handling, disposal or recovery.
9. **Biological Treatment:** means composting, anaerobic digestion, mechanical-biological treatment, or any other biological treatment process for stabilising and sanitising biodegradable waste, including pre-treatment processes.
10. **Stabilised (stable)**: the degree of processing and biodegradation at which the rate of biological activity has slowed to an acceptably low and consistent level and will not significantly increase under favourable, altered conditions
11. **Mixed Solid Waste biological treatment facility**" shall mean a Solid Waste Management Facility that utilises organic waste recycling by producing compost or/and energy from the biodegradable portion of a mixed solid waste input stream.

It excludes Residual Waste treatment facilities which solely use mechanical processes ("Dirty MRFs") but includes facilities which incorporate autoclaves and associated treatment. It excludes In Vessel Composting and Anaerobic Digestion ("AD") facilities designed solely for the treatment of source segregated organic wastes - e.g. food waste, garden waste, industrial effluents etc.

1. **Compost Like product (CLO):** It is humus-like product of mixed solid waste biological treatment facility and it is also referred to as 'stabilised biowaste' or a soil conditioner; it is not the same as a source segregated waste derived 'compost' or 'soil improver' that will contain much less contamination and has a wider range of end uses
2. **Composting**: is the process of controlled decomposition of biodegradable materials (a mixture of various decaying organic substances, as dead leaves or manure) into a humus-like product under managed conditions that are predominantly aerobic and that allow the development of thermophilic temperatures because of biologically produced heat.
3. ***Anaerobic digestion*** (AD) is the process of controlled decomposition of biodegradable materials under managed conditions in the absence of oxygen, at temperatures suitable for naturally occurring mesophilic or thermophilic anaerobic and facultative bacteria species, that convert the inputs to biogas and digestate.
4. **Digestate:** The solid and/or liquid product resulting from the anaerobic digestion process and that has not undergone a post-digestion separation step to derive separated liquor and separated fibre.
5. **Competent authority:** A regulatory body authorised by the government of the Republic of Lebanon to monitor compliance with the national statutes and regulations and carry out duties on behalf of the government in compliance with the law.
6. **Solid Alternative Fuel (SAF):** selected materials from the municipal and similar waste streams that have a high calorific value and can be shaped in a form that is safely used for energy recovery. Alternative terminology is Refuse Derived Fuel (RDF) and Solid Recovered Fuel (SRF)

3. General requirements at production facility

1.1 3.1 Environmental Impact Assessment (EIA)

(1) Because SAF production is always a part of the processes in a Mechanical Recycling or a Mechanical – Biological Treatment plants, the environmental impact assessment requirements should follow the requirements of mechanical sorting and/or biological treatment facilities, as they are presented in the relevant regulations "Standards and Conditions for the composting and biological disintegration process" and "Standards and conditions for the Mechanical sorting process".

(2) Permitting agencies must be informed about the environmental risk assessment by the facility owner/operator during the permitting process. This environmental risk assessment should address both normal, unusual, and unplanned operating conditions. It should cover the entire lifecycle of the facility from initial construction to the point where the facility no longer poses a risk to the environment. The eventual submission of the Facility permit should form part of the environmental risk assessment and needs to be explicitly considered at the permitting stage.

(3) The environmental risk assessment must inform permitting agencies for at least the following issues:

- (a) Facility siting
- (b) Protection of soil and water
- (c) Nuisances and hazards
- (d) Accidents and emergency response

(e) Environmental monitoring system

(4) In addition, for the case of SAF, an environmental risk assessment is required for the final use of SAF as well as its supply chain. ANNEX 3 presents the details of the required environmental risk assessment for the SAF supply chain.

3.2 Planning and sitting considerations

Because SAF production is always a part of the processes in a Mechanical Recycling or a Mechanical – Biological Treatment plants, the planning and siting considerations should follow the requirements of mechanical sorting and/or biological treatment facilities, as they are presented in the relevant regulations "Standards and Conditions for the composting and biological disintegration process" and "Standards and conditions for the Mechanical sorting process".

4. Design and construction requirements

Because SAF production is always a part of the processes in a Mechanical Recycling or a Mechanical – Biological Treatment plants, design, construction and operational requirements should follow the requirements of mechanical sorting and/or biological treatment facilities, as they are presented in the relevant regulations "Standards and Conditions for the composting and biological disintegration process" and "Standards and conditions for the Mechanical sorting process".

Additional requirements for facilities that are producing SAF are presented in ANNEX 4.

5. Fuel quality and standard specification

The EU CEN/TC343 standards are the ones that should be applied in SAF operations and uses in Lebanon.

1.2 5.1 Fuel quality standards

Standard EN15359 should be applied for the quality of SAF in Lebanon. The classification scheme of fuels is using three major parameters: calorific value (economic information), chlorine (technical information) and mercury (environmental information). Using these three parameters the overall quality and value of a SRF can quickly be assessed as shown below.

Table 1 : Proposed classification of RDF/SRF in Lebanon

Property Category	**Classification Property**	**Unit**	**Statistical Measure**	**Classes**				
				1	2	3	4	5
Economy	Net calorific Value (NCV)	MJ/kg (ar)	Mean	≥25	≥20	≥15	≥10	≥3
				1	2	3	4	5
Technology	Chlorine	%w/w (d)	Mean	≤0.2	≤0.6	≤1.0	≤1.5	≤3.0
				1	2	3	4	5
Environment	Mercury	mg/MJ (ar)	Median 80th percentile	≤0.02 ≤0.04	≤0.03 ≤0.06	≤0.08 ≤0.16	≤0.15 ≤0.30	≤0.5 ≤1.0

1.3 5.2 Quality management

The standard EN 15358 describes the Quality Management System (QMS) for SAF production and trading that provides for continuous improvement, emphasizing the fulfilment of quality requirements. Quality Management Systems according to EN ISO 9001 cover the whole process from the point of waste reception to the point of delivery of SAF to the customer. Standard EN15357 on terminology, definitions and descriptions describes the terms in the standards for solid recovered fuels

1.4 5.3 Sampling protocols

Samples should be assessed in different periods to understand the seasonality of the feedstock. This mainly relates to: Season variance, Weather variance, and Customs variance. Sampling procedure design should be executed according to EN 15442:2011.

Methods for the preparation of laboratory samples of solid alternative fuels may be considered by using CEN EN 15443 and/or EN 15357:2011, Solid recovered fuels — Terminology, definitions and descriptions, should be considered.

ANNEX 5 presents the details for assessing the quality of SAF and guidelines for laboratory analysis.

1.5 5.4 Declaring conformity

Each producer of SAF should provide a written declaration of conformity according to the CEN/TC343 standards. The declaration should ensure that the SAF must comply with the following:

- it is classified according to the classification scheme of EN15359
- it meets the quality requirements described in EN15359
- its properties are specified according to the requirements of EN15359

The producer is obliged to use the template declaration of conformity as provided in EN15359.

2 ANNEX 1: The role of solid alternative fuels in solid waste management

The waste used as solid alternative fuel can be classified into four broad categories, which generally are associated with specific regulations and/or implementation constraints related to the materials:

- Municipal waste
- Biomass
- Non-hazardous industrial and commercial waste
- Other unclassified solid alternative fuels.

High calorific value materials, e.g. paper, plastics, etc. are destined for the production of a fuel that can be used in several applications, e.g. cement manufacturing, or energy production. Such fuels can be produced in two types of plants: Mechanical Recycling or Materials Recovery Facilities (MRFs) and Mechanical Biological Treatment (MBT) plants. MRFs receive, separate, and recover recyclable materials and/or solid alternative fuels. The (MBT) process combines mechanical treatment (crushing and sorting) with biochemical reaction (aerobic, anaerobic, and biochemical drying) of the mixed non-hazardous wastes. Mixed wastes are separated into three solid fractions: Recyclable materials, natural organics that are composted aerobically or anaerobically, and a solid alternative fuel. Organic materials, e.g. wastewater biosolids, food wastes, etc., can be processed either aerobically to produce a Compost Like Output (CLO) or anaerobically to produce biogas.

The issues related to composting and biological disintegration processes are subject of the “Standards and conditions for the composting and biological disintegration process”.

Solid alternative fuel (SAF) is a crucial element in waste management. SAF is produced from non-hazardous waste which usually has undergone a prior sorting process and it’s not technically suitable or economically feasible to be recovered.

Only those materials that can not be recovered for recycling are fit to be used for SAF production. This means that optimisation of recycling will leave less materials for the production of SAF. However, full recycling of such wastes as MSW, I&CW and C&DW is not possible. Optimised sorting facilities can recover up to 60-70% of input material, leaving space for SAF production.

SAF production, therefore, does not compete with recycling but is integral part of it. Whereas SAF is used in cement kilns, CHP plants and in other high efficiency applications, there is less need for fossil fuels and less waste volume for landfill disposal or mass burn incineration. Whereas SAF can be traded, the energy content of waste can be used at the spot where there is a true heat demand.

A main advantage of SAF is that it provides for flexible use of the calorific value in waste. SAF is stored and shipped as fluff or pellets. It is used in those places where there is an actual need for a fuel and where there is an actual demand of heat. SAF is used in combustion processes that are designed to generate heat and/or power. The efficiency of such processes is high. On the other hand, energy is needed to transform waste into SAF. The overall balance however is still positive.

There are several uses for solid alternative fuels. The viability of some of these is dependent on addressing any technical barriers for use of the fuel, the market appetite, commercial drivers around carbon trading and energy costs, renewable energy incentives and the cost of waste disposal (gate fees). The potential outlets are:

1. Industrial sectors like the cement industry and coal power plants where the use of secondary fuels substitutes fossil fuels (e.g. coal, pet-coke). This generates benefits in the form of less dependence on fossil fuels and lower environmental impact.
2. Purpose built incinerators with power or power and heat (CHP).
3. Co-firing with fuels like poultry litter and biomass
4. An upcoming end-use that is foreseen is the use of solid alternative fuels for thermochemical recycling processes. This could either be aimed at converting the waste into liquid or gaseous fuels or to convert it into platform chemicals to be used for the production of new products.

3 ANNEX 2: Waste streams excluded and suitable for SAF production

3.1 Waste excluded from SAF

1. Healthcare waste
2. Biomedical waste
3. Asbestos containing waste.
4. Electronic scrap and e-waste
5. Batteries
6. Explosives
7. Corrosives
8. Mineral acid wastes
9. Radioactive Wastes
10. Unsorted municipal waste

3.2 Waste suitable for SAF

1. Low value recyclables of (torn paper, plastic pieces, glass pieces, metal pieces etc.)
2. Garden or woody waste
3. Woody and plastic elements from Construction – Demolition waste
4. Soiled paper
5. Dirty cardboard
6. Textile
7. Thin film plastic
8. Mixed non-recyclable plastics
9. Multi-layered packaging & other composite materials not suitable for recycling
10. Dried Organic Fraction from MSW
11. Car tyres
12. Impregnated sawdust
13. Agricultural and agro-industrial waste
14. Wood Chips
15. Industrial non-hazardous waste that does not include any of the excluded streams

4 ANNEX 3: Environmental risk assessment for the SAF supply chain

The production of SAF in Mechanical Recycling or Mechanical Biological Treatment plants does not add any important environmental impacts on top of the overall impacts of those plants. However, the purpose of producing SAF is to find an end user (or "Off-taker") that will utilize its energy content. Thus, there is a need for special precautions and risk assessment for the following points:

Storage and preparation for transport (risk of fires, odor)

Transportation (risk of accident, loading and unloading)

Final use (risk during final storage, risk of pollution due to the SAF, environmental modeling of exhaust air composition and dispersion with and without the use of SAF).

A complete fire prevention plan should be integrated in any EIA for facilities that produce SAF and an emergency plan for the case of fire in the SAF storage should be elaborated and submitted as a part of the EIA.

5 ANNEX 4: Requirements for storage, transport, and safety

5.1 Storage and preparation for transport

SAF may be stored prior to onward Transportation, or at any (or multiple) stage(s) along the Supply Chain.Storage may be required in order to accumulate sufficient quantities of SAF before a Shipment can occur.

Operators must have an appropriate environmental permit in place permitting the storage of SAF. SAF must be stored in accordance with the permit conditions, and SAF must not be stored outside of permitted areas, in excess of permitted capacity, or for periods in excess of those set out in the permit.

Operators must have a suitable fire prevention plan in place where this is required as part of the permit.

To reduce the potential for nuisance and smell, and enable suitable recovery of SAF, operators should ensure that SAF is wrapped or containerised:

- sufficiently to prevent the loss of waste materials and littering during storage and transportation;
- sufficiently to prevent the leaking of leachate;
- sufficiently to prevent fly infestation and access by vermin;
- in a way that meets any conditions and specifications set out in the contract with the Off-taker; and
- in a way which makes it easy to handle and store.

The number of layers of plastic wrapping required to meet these recommendations will vary depending on the quality of the wrapping process, the thickness of the plastic film and the amount of handling that the bales will be subjected to. A minimum of six layers should be used for non-containerized RDF that is being handled multiple times through the Supply Chain, however, the precise number of layers is ultimately determined by the requirements of the haulers and Off-takers involved.

SAF should generally be stored for a total cumulative period – from initial production to final treatment – of no longer than 3 months, and only for between 3 and 6 months where additional preventative measures are put in place to reduce any adverse impacts of longer storage. Storage should only exceed 6 months from the date of production where a specific agreement is in place with the appropriate regulator. SAF may be stored at multiple points through the SAF Supply Chain and therefore cumulative storage times should be monitored. This could be achieved through date marking of SAF bales, or through adherence to a site Management System which includes a stock rotation procedure.

These measures should prevent degradation of SAF, seeping of leachate and fly or pest/vermin infestation. Bales should be inspected regularly, and storage times should be reduced if the RDF begins to show signs of degradation.

Where SAF is being stored an assessment should be made of the proximity of animal feedstuffs or food also in storage, and any risks that the SAF may present. Action should be taken to minimise those risks, and landowners (such as port Operators) and SAF Operators should consider additional biosecurity measures if necessary. These may include:

- storage away from animal feedstuffs or food as far as is practicable;
- storage for as short a time as possible where animal feedstuffs or food are stored in close proximity;
- regular monitoring and maintenance of the SAF and its wrapping to prevent cross contamination; and
- liason with owners of animal foodstuffs or food if spraying of insecticides is to be carried out.

SAF should be stored on an impermeable surface with sealable drainage to minimize the risk of leachate seeping into the ground and leading to water contamination or contamination of other storage areas.

Operators should have a robust fire prevention plan in place, regardless of whether this is an existing permit condition or required by the relevant regulator.

5.2 Transportation

SA may be transported within or outside the country. Transportation is typically done via one or more of the following methods:

• road

• rail

• sea

The key elements in relation to the transportation of SAF are:

- preventing the escape of waste – particularly in relation to careful Transportation of wrapped bales of SAF to prevent damage to the wrapping; and
- describing the waste accurately to ensure it is handled in an appropriate manner.

SAF must only be transported by registered carriers, and carriers must hold all relevant vehicle licenses.

5.3 Safety

Production, handling, storage, trade, sampling or analysis of SAF can be accompanied with certain health risks. These risks are described in Technical Report CEN/TR 15441.

The safety data sheet (SDS) for chemical products due to ISO 11014 is a means of transferring essential hazard information (including information on transport, handling, storage and emergency actions) from the supplier of a chemical product to the recipient of this product. For non-hazardous substances or products there is a gap in information duties. Solid Alternative Fuel is derived from non- hazardous types of waste, so prima facie there seems to be no need for preparing an SDS for SAF. In addition, the SDS due to ISO 11014-1 would not cover environmental or health risks in the stage of SAF production.

Standard EN 15590 specifies the method determining the current rate of aerobic microbial activity of SAF using the real dynamic respirator index (RDRI). The rate of aerobic microbial activity is an indication of the biological stability under the actual chemical and physical properties of the SAF.

6 ANNEX 5: Quality requirements and laboratory analysis guidelines

Data should be collected and analyzed. The 95% confidence level should be calculated according to the formulae:

$X = AM \pm 1.96 \times s/\sqrt{n}$

Where:

AM = arithmetic mean

s = standard deviation

n = number of measurements

1.96 is the functional characteristic of the normal distribution (95% confidence level)

6.1 Particle size analysis

The particle size of the samples should be determined by using EN 15415-3:2012. Screening used in MBT plants sorts waste particles mainly according to their size. Particle size may be further adjusted by further comminution of the waste (secondary shredding). Power plants operate best using solid alternative fuels with a particle size of 20 mm (median value), whereas cement plants can tolerate up to 30 mm. Based on quality specifications solid alternative fuels can have a particle size in the range of 5 mm to <300 mm, with the highest particle size applications being utility boilers (i.e.<10–200 mm in fluidized bed, <300 mm in grate firing) and hot disc cement kilns (HDF) at <120 mm.

Typically, defined quantities in particle size analysis are:

- cumulative fraction finer than d x, where x is the percentage (undersize fraction, underflow) passing through the screen/sieve with aperture size d.
- characteristic particle size d 63.2 corresponding to Y(d) = 0.632; in other words, the particle size that 63.2% of the cumulative fraction is smaller than (63.2% cumulative passing).
- nominal product size d 90 (i.e., aperture/particle size with 90% cumulative passing) or nominal top size d 95, which can be used to define the product size of comminution process or the upper size of a fraction retained between two consecutive sieves, and
- measure of uniformity (breadth) calculated as the slope of the linear fit trend in an RRSB grid diagram. The steeper the slope of the line, the tighter the size range of the particles. A narrow size range indicates finer shredding and grinding than coarser cutting, leading to a larger proportion of fine material.

6.2 Determination and specification of bulk density

Bulk density is defined as the mass of the fuel that can occupy a specific volume. Bulk density is considered to be the most important physical property of a fuel for both economic and technical reasons. The bulk density of solid alternative fuels is determined by the fuel preparation technique employed. This can include sorting, biological treatment, crushing, grinding, shredding, separation, screening, drying, compacting etc. Bulk density is included within the technical attributes as solid alternative fuels with a lower bulk density can have the following disadvantages:

the calorific value per unit volume is lower when bulk density is low; controlling the process may be difficult; feeding control has to be accurate; a large amount of space may be required to store the solid alternative fuel; transport costs may be increased as more fuel would be required; and fuels with a low bulk density may be unsuitable for some technologies. Some applications require a lower bulk density to enable the solid alternative fuels to be blown into the furnace using air pressure.

The fuels should have a mean bulk density of >100 kg/m^3, depending on the desired application and class of the fuel. The bulk density of solid alternative fuels should be determined using CEN/TS 15401:2010.

6.3 Proximate analysis

6.3.1 Determination and specification of moisture content

Moisture content is used to describe the water present in solid alternative fuels. Moisture content is included in the economic attributes as the amount of moisture present in fuels impacts on the heating value. The heating value of the fuel decreases with increased moisture content. In addition, moisture content is an important fuel parameter as:

- a higher moisture content increases the volume of flue gas produced per energy unit, requiring larger waste heat boilers and flue gas cleaning equipment.
- high moisture content will reduce the combustion temperature, hindering the combustion of the reaction products resulting in higher emissions and higher fuel quantities. Supplementary fuel may also be required to maintain combustion temperature; and
- the presence of moisture in solid alternative fuels will influence the behavior of the waste during the primary conversion stage in a gasification/pyrolysis plant and will also impact on the properties and quality of the syngas produced.

Moisture content is typically measured by heating the fuel to 105°C and measuring the weight loss. It is expressed using the unit % wt/wt. The moisture content of solid alternative fuels can be measured using either BS EN 15414-1: 2010 or BS EN 15414-2: 2010.

When the food waste content in MSW is around 50% or more, then the biodrying process followed by mechanical separation is considered to be most advantageous for solid alternative fuels production as it can reduce the moisture content to around 15% wt. Air drying of solid alternative fuels is suggested for samples with moisture content greater than 20% w/w.

6.3.2 Determination and specification of volatile matter

Volatile matter is essentially a measure of the non-water gases formed from a solid alternative fuel sample during heating. It is measured as the weight percent of gas (emissions) from a fuel sample that is released during heating in an oxygen-free environment, except for moisture (which will evaporate as water vapor), at a standardized temperature. Results are presented in weight percent. Volatile matter should be determined by using EN15402:2011.

Biomass materials indicate between 50 and 80% volatile matter. Solid alternative fuels from municipal solid wastes indicate volatile matter between 75 and 95%.

6.3.3 Determination and specification of ash content

Ash is the inorganic and incombustible mineral fraction of solid alternative fuels that is left after complete combustion. The mineral fraction consists of non-combustible minerals which are contained in the fuel and contaminants which can be added to the fuel during processing, such as dirt and dust. Typical elements present in ash are silicon (Si), aluminium (Al), iron (Fe), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), sulphur (S) and phosphorous (P). The concentration of each element varies according to the composition of the fuel. Ash content is included within the technical attributes of solid alternative fuels because:

- fuels containing a high ash content will require an efficient dust removal system to reduce the amount of particulate emissions.
- Fuels with a high ash content will have a lower calorific value and
- the ash sintering, softening and melting temperature is determined by its elemental composition and therefore it is an important characteristic in determining the combustion temperature to avoid problems with ash handling.

The fuels should have a mean ash content (dry) of <50 wt.%, depending on the desired application and class of the fuel. Ash content of solid alternative fuels can be determined by using EN 15403.

6.4 Ultimate-elemental analysis

Elemental analysis (C, H, N, S) should be conducted using EN14507:2011/ EN15408:2011. This information is used to assess the environmental impact, but also, to evaluate the heat potential of the fuel. Trace elements (As, Ba, Be, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Sb, Se, Tl, V and Zn) should be determined using EN 15411, and sulphur (S), chlorine (Cl), fluorine (F) and bromine (Br) content using EN 15408.

There are environmental concerns because these metals are volatised as chlorides and oxides during combustion. A large proportion of volatile metals present in the solid alternative fuels would be captured and contained in air pollution control (APC) residues while the remaining are emitted through the stack. Nonvolatile metals are contained within the bottom ash. Especially important are the chlorine and mercury content of the fuel. The Cl content is a measure of the potential corrosion, slagging and fouling effects in boilers. The presence of chlorine can also increase emissions of hydrochloric acid (HCl) and cause the formation of Polychlorinated Dibenzodioxins (PCDD) and Polychlorinated Dibenzofurans (PCDF). Chlorine is a highly electro-negative halogen and is typically present in the following wastes:

- organic food waste which contain salts such as sodium chloride (NaCl) and potassium chlorides (KCl).
- plastic bags which are halogenated.
- polyvinyl chloride (PVC) which are present in pipes, insulation cables, and as a substitute for painted wood, films etc.
- paper and wood pulp which have been bleached, and
- industrial solvents (e.g. degreasers, cleaning solutions, paint thinners, pesticides, resins and glues).

Most of these wastes can be present in solid alternative fuels and higher amounts would result in higher chlorine content. The chlorine content of the whole of the fuel can be diluted by mixing with other waste fractions other than those listed above.

If the solid alternative fuels are to be used in the cement kiln, the maximum amount of chlorine content should be <0.7%. Higher amounts of chlorine may result in the excessive formation of salts (cement kiln dust) that are volatilized in the kiln and then solidify and can foul and corrode the downstream unit (in the direction of gas flow) of the calciner.

The Hg content (one of the most significant global environmental pollutants because of its medium and long term impacts on health) is a measure of the potential toxicity released in the environment as its high volatility makes it the most challenging to capture in the air pollution control systems treating the flue gas after combustion. Mercury is typically found in the following types of wastes:

- industrial sludge and filter cake, and
- Waste Electrical and Electronics Equipment (WEEE).

6.5 Determination and specification of heating value

The calorific value of any fuel describes the amount of heat or energy generated when it is completely combusted. It is expressed as a gross calorific value (GCV) and net calorific value (NCV). NCV is determined by calculation and is equal to the GCV minus any heat lost due to moisture present in the fuel and various chemical processes. The NCV is more representative of the heat available in practice when fuels are combusted in boilers and furnaces. The NCV ensures that the calorific value takes account of the moisture content as received at the laboratory before any processing or conditioning takes place, giving a more representative result. The NCV of solid alternative fuels can be calculated and reported as set out in 'BS EN 15400:2011, 'Solid recovered fuels - Determination of calorific value' or ASTM D2015-96. If NCV data is available on a dry basis, the following equation can be used to assess the NCV:

$$NCV_{ar} = (NCV_d \times (100 - M_{ar})/100) - 0.02443 \times M_{ar}$$

Where,

NCVd = Net calorific value, dry basis (MJ/Kg)

NCVar = Net calorific value, as received basis (MJ/Kg)

Mar = Moisture content, as received basis

0.02443 represents the correction factor of the enthalpy of vaporization of water (constant pressure) at 25°C (in MJ/kg per 1 wt% of moisture).

6.6 Determination and specification of biomass content

The biomass content of solid alternative fuels consists of its biodegradable fraction and is usually represented by the percentage of biogenic carbon (C-14) in comparison to the total carbon present in solid alternative fuels. Biomass content is considered within the economic characteristic because:

- The electricity and/or heat generated from the biodegradable fraction of waste is characterized as renewable energy and may be eligible for receiving support from the government.
- Knowing the biomass/biodegradable content of waste could help operators and end users quantify the landfill cost saved as a result of diversion of these wastes from landfill.

The methods for determining the biomass content in solid alternative fuels are set out in 'BS EN 15440:2011 – Solid recovered fuels – Method for determination of biomass content'. These methods should be used to measure the biomass content in solid alternative fuels and include selective dissolution, manual sorting or a measure of C14 content. The fraction of biogenic content in solid alternative fuels should be expressed as the percentage of biogenic carbon content to total carbon content (wt/wt % as received). The combustion gases generated during the calorimetry tests when determining the calorific value can be collected and analyzed by means of the ASTM C-14 analysis for the distribution of biogenic and fossil-based carbon in the fuel. The fuels should have at least 50% biomass content (as received), depending on the desired application and class of the fuel.

6.7 Improving the quality of the solid alternative fuels

The quality of solid alternative fuels can be improved by concentrating only suitable combustible fractions (such as plastics, packaging composites, textiles, etc.) and removing physical (glass, stones, ferrous and non-ferrous metals) contaminants. Materials with high Cl and lead (Pb) content are undesirable and their removal is seen as a priority. Efficient separate collection of materials made of polyvinylchloride (PVC: pipes, sheets, panels, tiles, toys, paints) and of others that contain chloride such as bleached paper and industrial solvents (e.g. degreasers, cleaning solutions, paint thinners, pesticides, resins and glues) could reduce the Cl content. Separate collection of waste electrical and electronic equipment (WEEE), thermometers, batteries, paints and electroplated metals can reduce the Hg and cadmium (Cd) contents in the residual municipal solid waste and Commercial and Industrial Waste and Construction and Demolition waste streams, thereby improving the relevant solid alternative fuel class. Optical separators, and Near-infrared (NIR) technologies used in MBT plants could potentially remove plastics with high Cl content, such as PVC.